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ABSTRACT

The effect of pictures on reading comprehension under different levels of text organization was investigated. Sixth graders (N=132) read three science passages, presented with or without pictures representing text content. Picture condition was crossed with three levels of text organization. Multiple-choice test scores were analyzed using reading comprehension scores from the California Achievement Test as a covariate. This analysis revealed significant main effects for picture, organization, and text; an expected interaction of picture and organization did not occur. Thus, there was evidence that pictures facilitate comprehension for some science texts, but no evidence to support a hypothesis that pictures would be more helpful for less well organized texts than for better organized texts. (Author/DH)

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THE EFFECTS OF ADJUNCT PICTURES ON COMPREHENSION OF GRADE SIX SCIENCE TEXTS UNDER THREE LEVELS OF TEXT ORGANIZATION

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Running Head: PICTURES AND COMPREHENSION OF TEXT

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Abstract

We investigated the effect of pictures on reading comprehension under different levels of text organization. Sixth graders (N = 132) read three science passages, presented with or without pictures representing text content. Picture condition was crossed with three levels of text organization. Multiple-choice test scores were analyzed using reading comprehension scores from the California Achievement Test as a covariate. This analysis revealed significant main effects for picture (p = .001), organization (p = .04), and text (p < .0001). An expected interaction of picture and organization did not occur (p = .87). Thus, there was evidence that pictures facilitate comprehension for some science texts, but no evidence to support a hypothesis that pictures would be more helpful for less well organized texts than for better organized texts.

The Effects of Adjunct Pictures on Comprehension of Grade Six Science Texts Under Three Levels of Text Organization

The purpose of this study was to investigate whether pictures added to science texts would increase sixth graders' reading comprehension for the texts. An additional purpose was to examine whether text organization is a factor in the degree to which pictures facilitate comprehension.

In an investigation of this problem, 132 sixth grade children from a school district near Phoenix, Arizona were assigned randomly to one of six experimental groups. Subjects read three science passages, presented with or without pictures representing text content. For one-third of the subjects within each picture condition, passage content was organized well, for one-third, content was organized moderately well, and for the rest, content was organized poorly. Comprehension was measured with a multiple-choice test.

Research on Pictures and Prose Comprehension

Results of research are inconsistent concerning effects of adjunct pictures on reading comprehension. In an early review, Samuels (1970) reported that adding pictures to text did not result in increased reading comprehension. However, several reviewers have concluded

recently that pictures have at least a slight facilitative effect on comprehension (e.g., Readance & Moore, 1981; Schallert, 1980). Other reviewers have noted the great variability in results from study to study, and have cautioned that few interpretations can be made until more carefully designed research is conducted (e.g., Brody, 1981). Results obtained have included reports of no facilitation, or of a general facilitative effect or facilitation under limited conditions.

No facilitation. In early studies of basal readers, Miller (1938) and Weintraub (1960) reported that adjunct pictures do not facilitate comprehension. However, Schallert (1980) noted that pictures presented in studies using basal readers often are irrelevant or related vaguely to the text; thus, it is not surprising they add little to comprehension. Also, Weintraub (1960) claimed that for poor readers, text with pictures yielded lower comprehension than text without pictures, but a review of the data has shown that claim to be in error (Koenke, 1968).

A few more recent studies have also reported that adjunct pictures do not facilitate reading comprehension (Duchastel, 1980; Flagg, Weaver, Fenton, Gelatt, & Pray, 1981). The specific reasons are unclear for the

discrepancy between these studies and the many in which facilitation has been found. Apparently the research question is complex, involving the interaction of a number of reader, text, and picture variables.

Conditions of facilitation. Consideration of studies in which facilitation has been found enables us to begin to identify relevant variables and the conditions under which adjunct pictures facilitate comprehension of prose. First, facilitation can be limited to specific tasks used to measure comprehension. For example, Haring and Fry (1979) reported facilitation when recall of main ideas was measured, but no facilitation for recall of details. Similarly, Donald (1979) reported facilitated recall of main ideas but no improvement in performance on questions that required inferences. In a study which included such diverse tasks as answering multiple-choice questions, defining terminology, and labelling parts of a diagram, Dwyer (1967) reported facilitation for some comprehension tasks, but not others.

Whether the comprehension task is limited to information specifically illustrated may also be important. Some researchers have reported facilitation only for text content specifically illustrated, with no

effect on comprehension of information not illustrated (Peeck, 1974; Schallert, 1980; Vernon, 1953). However, other researchers have reported facilitation of both illustrated and non-illustrated information from text (Rusted & M. Coltheart, 1979; Rusted & V. Coltheart, 1979).

Facilitation may also be affected by whether testing is immediate or delayed. For example, Duchastel (1981) reported facilitation of cued recall only for a delayed test.

Finally, facilitation has varied with characteristics of the subject. Several studies have yielded different effects as a function of subject age or educational level (Koenke & Otto, 1969; Rasco, Tennyson, & Boutwell, 1975; Readance & Moore, 1981). Analyzing data from a study by Rohwer and Harris (1975), Schallert (1980) reported that the picture effect varied with the SES of the subject. Finally, Flagg et al. (1981) reported an interaction between picture condition, reading skill, and the importance of information within a passage.

Clearly, inconsistent results of research on adjunct pictures and reading comprehension reflect a complex interaction of variables. Whether adjunct pictures

facilitate comprehension may depend on characteristics of the text, the illustration, the reader, and the comprehension task--and the various possible interactions of all these variables. A text may be narrative or expository, one sentence or many paragraphs, easy or difficult to comprehend without illustrations. There may be great variation in the proportion of ideas or words from a text that are represented by illustrations and the kind of information represented (e.g., main ideas, details, action sequences, or individual elements from the text--or even ideas related only vaguely to the text). Illustrations may be line drawings, photographs, or shaded drawings. Readers may differ in age, SES, vocabulary, intelligence, reading comprehension, and prior knowledge. Measures of comprehension which have been used include free recall, cued recall, and multiple-choice questions. Also, immediate and delayed measures have been used.

Organization of Prose Passages

In addition to the complexity of variables just discussed, another complication is that illustrations may serve a number of different functions in prose comprehension. The relative importance of various functions may vary with characteristics of the text,

illustration, and reader. Discussing both illustrations and visual imagery in prose comprehension, Levin (1979) listed eight possible functions. In order of increasing benefit to comprehension, these functions include: (a) decoration, enhancing a book's attractiveness, (b) remuneration, increasing a book's sales, (c) motivation, increasing reader interest in a text, (d) reiteration, providing additional exposure of text information, (e) representation, making text information more concrete, (f) organization, making text information more integrated, (g) interpretation, making text information more comprehensible, and (h) transformation, making text information more memorable. These functions are not mutually exclusive--one picture may serve several functions.

The organization function, making text information more integrated, is especially plausible on the basis of four kinds of evidence in the research literature. First, there is extensive evidence that passage organization affects what is recalled (Frase, 1969; Meyer & Freedle, 1984; Steingart & Glock, 1979). There are also some indications that a picture can produce effects on comprehension of written prose like those effects produced by a verbal organizer (Bernard, Petersen, &

Ally, 1981). Similarly, there is evidence that pictures which provide an organizing context facilitate comprehension more than pictures which contain the essential elements but not the relations between them (Borges & Robins, 1980; Bransford & Johnson, 1972; Levin, Shriberg, & Berry, 1983). Finally, there is evidence that instructions to form mental images can improve organization of recall protocols for written prose (Steingart & Glock, 1979).

Given the complex results of the research on pictures and prose comprehension, and the evidence suggesting that pictures may help a reader organize text information, we designed this study to further examine the effects of pictures on comprehension and to test a specific prediction about the importance of passage organization in tempering the effects of pictures on prose comprehension. First, we expected pictures to facilitate comprehension overall. Second, to the extent that facilitation results from pictures helping a reader organize text information, we expected pictures to be less helpful for texts in which logical organization of information was obvious in the texts themselves than for texts in which clear organization was absent.

The manipulation of organization adopted in this

study, i.e., randomization of sentence order, was designed to obscure the text's underlying relationships, making the relationships between bits of information less obvious. This manipulation of passage order is in accord with Steingart and Glock's (1979) statement that a well-organized text is one that requires "little sentence reorganization to clarify the text's underlying relationships," and a poorly-organized text is "one that requires extensive reorganization of the sentences" to clarify these relationships (p. 68). Thus, this randomization was intended to hold constant the difficulty level on traditional measures (i.e., sentence length, word length, vocabulary) while changing the degree of difficulty related to organization. Although crude, this manipulation of organization has been shown to affect comprehension (Frase, 1969; Steingart & Glock, 1979) and seemed suited to a preliminary study of adjunct pictures and text organization.

Method

Subjects and Design

One hundred thirty-two sixth graders (68 females and 64 males) from a school district within 30 miles of Phoenix, Arizona, served as subjects. The neighborhood served by this school district is predominantly lower to

middle class.

There were two between-subjects independent variables: (a) picture condition (picture, no picture) and (b) passage organization (well organized, intermediate, and poorly organized). A within-subjects variable, text (solar still, cement, plants) was included to provide additional information about the generality of the picture and organization effects. The dependent variable, reading comprehension, was represented by scores on a multiple-choice test.

Subjects were selected randomly from the entire sixth grade and were assigned randomly to six experimental groups. However, two conditions were imposed upon this random selection and assignment. First, students with reading scores below one standard deviation below the mean on the Reading Comprehension subtest of the California Achievement Test were not included. Second, approximately equal numbers of males and females were assigned to each group. The six experimental groups, representing all combinations of picture condition and organization, were as follows: (a) well-organized passages, pictures, (b) well-organized passages, no pictures, (c) intermediate passages, pictures, (d) intermediate passages, no pictures, (e)

poorly organized passages, pictures, and (f) poorly organized passages, no pictures. Subjects in each group received passages on all three topics (solar still, cement, plants); within each of the six experimental groups, each passage appeared an approximately equal number of times in first, second, and third position.

Materials

Texts. Three expository texts were used. For each text, well-organized, intermediate, and poorly organized versions were written. One text, "Taking Salt Out of Water," was a description of how to build a solar still for removing salt from water; this text was based on a passage from Science for Children (Hubler, 1974). A second text, "Insectivorous Plants," described how several plants trap and digest insects. A third text, "Cement," described the production of cement and the chemical processes involved in hardening. The texts on plants and cement were based on passages from Science in Everyday Life (Vergara, 1980). The three texts were revised from the original versions to yield passages of approximately 300 words each with a level of reading difficulty appropriate for sixth graders. Specifically, Dale-Chall readability (Dale & Chall, 1948) was 5.57 for the passage on building a solar still, 5.88 for the

passage on plants, and 5.64 for the passage on cement.

The well-organized version of each passage was written in standard prose. A variation of the organization manipulation described by Steingart and Glock (1979) was applied to generate the poorly organized texts. Specifically, the poorly organized version of each passage contained the same sentences as the well-organized version; however, sentence order within each paragraph was scrambled. Passages at the intermediate level of organization were like the poorly organized passages except that the correct first sentence of each paragraph had been returned to its proper position. For paragraphs six or more sentences long, the correct last sentence was also returned to its proper position.

Pictures. Line drawings were constructed to represent as much passage content as possible, with a special attempt to represent sequences of events and relations between parts. Clarity of these drawings was examined by asking four fifth graders to describe each picture; no difficulties were apparent.

Recognition test. A multiple-choice test was constructed, consisting of 36 items, 12 from each of the three passages. Each question contained one correct

alternative and three distractors. Some questions required information from more than one sentence. For these questions, number of sentences intervening between the target sentences was balanced across the well-organized, intermediate, and poorly organized versions of each passage.

Stimulus booklets. Passages, pictures, and recognition tests were assembled in spiral-bound booklets. Each passage appeared on the left side of the booklet; when a passage was accompanied by a picture, the picture appeared on the facing page to the right of the passage, so that picture and passage were visible simultaneously. When a passage was not accompanied by a picture, the page facing the passage was blank. Each picture or blank page was followed by two pages containing the multiple-choice questions for the passage. Each booklet contained all three passage topics and question sets, and a time-filling questionnaire designed to keep children who finished the passages quickly from distracting those who needed more time.

Procedure

Subjects completed tasks in their regular classrooms, in groups of approximately 25. Each subject was given a stimulus booklet and instructed to read the

passages carefully and answer the questions without looking back at the passages. The classroom teacher told subjects when to open the booklets and begin reading. When the experimenter saw that all subjects had finished answering the multiple-choice questions for the third passage, she instructed the subjects to stop working and collected the booklets.

Results

Scores on the multiple-choice test were analyzed with a 2 x 3 x 3 (Picture x Organization x Text) analysis of covariance; reading comprehension scores on the California Achievement Test served as the covariate, with text as a repeated measure. Adjusted cell means and standard deviations are presented in Table 1.

Insert Table 1 about here

Adjunct pictures facilitated comprehension of science passages. For the main effect of picture condition on comprehension scores, the analysis of covariance yielded an $F(1, 125)$ of 10.61, $p = .001$. Thus, the adjusted mean score for subjects receiving adjunct pictures (7.95) was significantly higher than the adjusted mean for subjects not receiving pictures (6.88),

with the picture effect accounting for approximately 5% of the variance of the adjusted comprehension scores.

Organization, defined in terms of sentence order, did not interact with presence or absence of adjunct pictures, $F(2, 125) = 0.14$, $p = .87$. Thus, the prediction that pictures would be more helpful for less well organized text than for better organized text was not supported.

An assumption underlying the design of this study was that manipulation of sentence order would affect comprehension. This assumption was supported by a significant main effect for organization, $F(2, 125) = 3.22$, $p = .04$, with organization accounting for approximately 3% of the variance of the adjusted comprehension scores. Post hoc contrasts between the adjusted means for the three levels of organization revealed only one significant contrast; i.e., the adjusted mean for the well organized passages (7.99) was significantly higher than the adjusted mean for the poorly organized passages (7.00), $F(1, 125) = 6.02$, $p = .0156$.

Although not addressed in the hypotheses, text was included as a repeated measure in the analysis of covariance. This analysis yielded an $F(2, 252)$ of 10.50,

$p < .0001$, indicating that text had a significant main effect on comprehension. Post hoc contrasts between adjusted means for the three texts indicated that the adjusted mean for the passage on plants (7.98) was significantly higher than the adjusted means for both the passage on building a still (7.26) and the passage on cement (7.02), with $F(1, 126) = 11.69$, $p = .0008$, and $F(1, 126) = 16.67$, $p = .0001$, respectively. Adjusted means for the passages on cement and building a still did not differ, $F(1, 126) = 1.36$, $p = .2459$.

The analysis also revealed a significant Text x Picture interaction, $F(2, 252) = 4.45$, $p = .01$. This interaction is plotted in Figure 1. Pictures appear to have been more helpful for the passage on the solar still

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Insert Figure 1 about here

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than for the other two passages. This apparent difference was confirmed by a test of simple effects for picture condition at each level of text. For the passage on building a solar still, the picture effect was significant, $F(1, 125) = 21.03$, $p < .0001$. However, for the passages on cement and on plants, the picture effect was not significant, $F(1, 125) = 3.13$, $p = .079$, and

$F(1, 125) = 2.26$, $p = .135$, respectively.

Results of Item Analysis

An item analysis was run on the total set of 36 multiple-choice questions. Reliability, estimated with Kuder-Richardson's formula 20, was .86. The average proportion of respondents answering an item correctly, average item difficulty, was .61. Average item discrimination was .42. Average item reliability, computed as two times the product of item standard deviation and item discrimination, was .38

Discussion

The results provide evidence that, for sixth graders, pictures can increase reading comprehension for science texts. However, the conditions under which such facilitation occurs remain unclear.

The manipulation of organization used in this study, while it did affect comprehension, did not produce the expected Organization x Picture interaction. Thus, there was no evidence that pictures were more helpful for texts in which sentence order was manipulated to obscure the underlying relationships than for texts in which these relationships were more obvious. However, the main effects for picture and organization were small, accounting for approximately 5% and 3% of the variation

in adjusted comprehension scores, respectively; these differences may not have been large enough to provide an adequate test for an interaction between picture and organization.

While it may be true that text organization does not influence the effectiveness of adjunct pictures, it may also be true that a different and more refined analysis of organization will reveal a relationship between organization and the usefulness of adjunct pictures. Rather than looking at degree of organization, we may need to look at various types of organization, such as those described by Meyer and Freedle (1984).

The questions of primary interest in the design of this study concerned the effectiveness of pictures in increasing reading comprehension and the interaction of pictures with passage organization. However, since each subject read three different passages, a within-subjects variable was included in the analysis to provide secondary information about the generality of the picture and organization effects. The significant main effect for this text variable was not surprising. Since a comparison of the three texts was not part of the original design of the study, uncontrolled differences were numerous. The passages themselves were equated only

on approximate length and Dale-Chall readability, and by the general content category of science topics. Also, comparison of the three passages is confounded with the use of three different sets of multiple-choice questions. Similarly, different pictures accompanied each passage, and comparability of the pictures is unknown.

These uncontrolled differences and confounding of passage, picture, and comprehension measure also make it impossible to interpret clearly the Picture x Text interaction, which may reflect any of a number of differences, alone or in combination. For example, an obvious content difference between the three passages is the amount of spatial information. While content of all three passages was fairly concrete, the passage on the still contained much information concerned with spatial relations; i.e., much content in the passage on the still referred to the location of specific components of the still and of water during the process of evaporation and condensation. As pictures seem especially suited for presenting information about spatial relations, differences in proportion of spatial information may account for the differential helpfulness of pictures for the three passages. The passage on plants contained some information on spatial relations, but, because of the

structure of the text, this information was specific to each of the three plants described. Thus, pictures of the plants may have provided fewer visual links between bits of information than was the case for the passage on building a solar still. Finally, the passage on cement had few references to spatial relations.

Similarly, while an attempt was made to illustrate as much content as possible and to write questions which tapped illustrated information, for some kinds of information, it is difficult to determine objectively whether an illustration is adequate. Consequently, differences in proportion of content illustrated, or proportion of target information illustrated, may have affected comprehension scores. Development of decision rules for determining when idea units have been illustrated may render this variable more controllable in future studies. Meyer's (1975) analysis of prose structure provides a system for reliable identification of idea units.

Along with proportion of idea units illustrated, repetition of information within a picture may also be important. In the picture for the passage on the solar still, some basic information about the still was repeated two or three times with minor variation. Such

repetition within a picture was slight or nonexistent for the other topics illustrated.

The pictures for the three passages may also have differed in clarity. Perhaps the picture for the passage on the solar still was drawn more clearly, so that the information provided by the picture was more easily perceived or interpreted.

As mentioned above, different sets of multiple-choice questions were used with each passage, complicating interpretation of the Text x Picture interaction. Beyond interpretation of this interaction, the manner in which comprehension is measured may be of general importance, as it may be related to the extent of advantage for pictures. The present test items included information which may have cued the subject to the correct response. A recall test scored for number of idea units accurately reproduced is likely to yield greater variability in comprehension scores and provide a more rigorous test of the picture or picture-by-organization effect.

In summary, pictures can increase reading comprehension of science texts for sixth graders. There was no evidence that pictures were more helpful for texts in which sentence order deviated from the usual order than for texts in which normal sentence order was

preserved. However, a different and more refined analysis of text structure, identifying various organization types rather than simply describing the degree of organization, may clarify the relationship between text organization and the usefulness of pictures.

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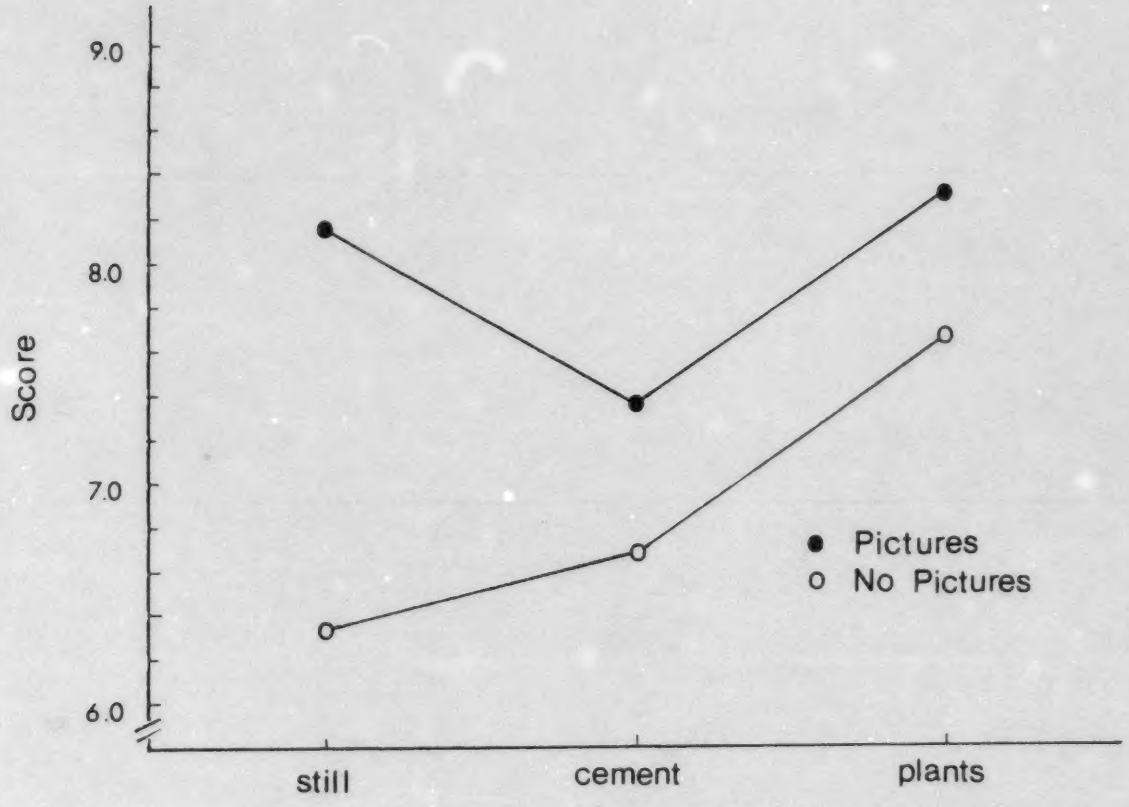
Table 1

Comprehension Scores: Adjusted Means and Standard Deviations

		Organization		
		Good	Intermediate	Poor
		Solar Still		
Pictures	M	8.84	8.03	7.65
	SD	2.72	2.10	2.63
No Pictures	M	7.07	6.38	5.59
	SD	2.18	2.05	2.04
		Cement		
Pictures	M	7.98	7.30	6.83
	SD	2.92	2.29	2.19
No Pictures	M	7.11	6.33	6.54
	SD	2.51	1.83	1.98
		Plants		
Pictures	M	9.11	7.80	8.06
	SD	2.30	2.81	2.39
No Pictures	M	7.84	7.74	7.32
	SD	3.07	2.31	1.90

Figure Caption

Figure 1. Adjusted mean comprehension score as a function of picture condition and text.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